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Statement of
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Subcommittee on Science, Technology, and Space
Committee on Commerce, Science, and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee, it is my pleasure to appear before you today to discuss one of my highest priorities – achieving affordable access to space.

<u>The Need for Affordable, Reliable Access to Space</u>

In coming decades, NASA envisions the space frontier as a busy crossroads of U.S.-led international science, research, commerce, and exploration. The potential for the future seems almost limitless. However, without affordable and reliable access to space, this potential will remain unrealized. Today, we are handicapped by outdated launch vehicle technology and a people-intensive, expensive infrastructure. Corporate- and university-sponsored research and space business development are impeded by high costs. Our civil space program is seriously limited by operations costs.

Currently, NASA uses the Space Shuttle, the world's first partially reusable launch vehicle, for its human space missions. We also fly robotic missions on commercially procured expendable launchers. NASA's total launch costs exceed $4 billion per year, nearly one third of our budget. This is too much. NASA is not alone in being affected by the high cost of space transportation. The Department of Defense spends about $1.5 billion per year on launch, and the worldwide commercial market in 1997 was almost $3 billion.

We are faced with these huge costs because as a country we have not adequately addressed the issue of affordable, reliable access to space. U.S. commercial launchers are based on technology and designs nearly half a century old. We developed the Atlas, Delta, and Titan ballistic missiles during the Cold War, and today they remain the workhorses of the launch fleet. These staged, throw-away designs are struggling to compete successfully against newer, more efficient designs from overseas suppliers. They are expensive, with launch costs ranging from $50 million to $400 million. Even the Shuttle's technology is over 30 years old, and it costs about $450 million per launch. Your laptop computer is more sophisticated than the computer on board the Shuttle.
In addition to high costs, reliability of commercial expendable launchers is woefully

inadequate. Expendables have had a consistent level of reliability in the 90% range. This unreliability drives up insurance costs; on some vehicles the premium for launch insurance is 30% of the value of the vehicle. Unreliable launchers also mean that commercial space endeavors are late reaching operational status: delaying the start of commercial services, delaying the first revenue, discouraging investors, and hampering the commercial use of space. Recently, due to launcher unreliability, a very promising communications constellation delayed the start of commercial service, which means increased costs and higher prices for the users. Many civil exploration missions, national security missions, and commercial endeavors can succeed or fail based on the reliability of a single launch.

Cycle time for current launch vehicles is atrocious. The time from a user's initial manifesting request to the actual flight should be weeks, not years. Current launch vehicle manufacturers require two years to build their vehicles. Modern commercial spacecraft can be built within 18 months, and this time is shrinking. The time from project initiation to launch requires capital, and capital is expensive. We must have vehicles that are more responsive to users' needs and schedules.

The infrastructure our launchers use is also decades old, and contributes to the cost problem. We are using the same ranges and launch complexes that we built during the Cold War. The Federal Ranges use old, expensive radars to track every launch. Scheduling is cumbersome and unresponsive. Reconfiguration from one type of launcher to another takes days, not hours. The launch pads use antiquated communications systems. Expensive, highly toxic, environmentally hazardous propellants must be stored and transported on the Ranges. The entire infrastructure is people-intensive, hard to maintain, and expensive. The Air Force spends $400-500 million a year on Range maintenance. This equates to a hidden cost to the government of nearly $13.5 million per flight. Range safety costs can be $1 million for small launches, absolutely prohibitive for many of the small, innovative experiments we want to fly. It is not cost-effective to spend $1 million on range safety for a university-sponsored experiment that costs half that.

Contrast this picture with that of U.S. spacecraft technology. A communications satellite today has twenty times the capacity, yet costs the same, as a satellite built ten years ago. Within the next ten years, today's cost of $20,000/mHz/year will further decline to about $3,000/mHz/year. Yet the cost to launch those satellites has remained nearly constant over the last ten years and is not predicted to decline dramatically within the next ten years. We face a similar situation with reliability. A first-generation commercial spacecraft would last for one year on-orbit; today they are predicted to last 15-20 years and often last beyond that. As I mentioned above, commercial launchers' reliability is consistently around 90%. Technical upgrades have been made to U.S. expendable launch systems to obtain every possible performance gain and to introduce updated technology such as composites and advanced avionics; however, performance, not cost reduction, has been the driver.

The U.S. Air Force Evolved ELV (EELV) program seeks to address, by 2001/2002, new launch systems which will cost 25-50% less than current systems. These systems can offer moderate launch cost reductions but are not sufficient to enable the expansion of access to space envisioned by NASA and required by this country.

Every dollar the U.S. spends on launch is one less dollar we can spend on exciting exploration missions, textbook-changing science missions, enhanced national security, improved global communications, and life-changing technology advancement. Imagine the revolution in space activities if launch costs and reliability had changed as much as those in the satellite industry. Why haven't they?

In the last 25 years, while revolutionizing the communications and remote sensing satellite industry, the U.S. has developed one major launch vehicle (the Space Shuttle) and rocket engine (the Space Shuttle main engine). In the same timeframe, other nations have developed 27 rocket engines and dozens of launch vehicles. Our launchers, once dominant, only supplied 40% of the worldwide commercial market in 1997. If nothing changes, we will impede the growth of the booming communications industry, preclude new business opportunities in space and restrict the civil space program that already has returned so much to this Nation. It is time to change the equation.

<u>A Vision for the Future</u>

It is 2025. Space has been brought fully into the sphere of human activity. There are manufacturing facilities in space, creating new materials that are used for businesses on Earth that we couldn't imagine 30 years ago. Orbiting biomedical labs make stunning contributions to the medical and pharmaceutical industries. Commercial remote sensing services make a healthy profit while improving our quality of life. Air traffic control is space-based. Communications and navigation are businesses, not the province of government. Space tourism is affordable. The International Space Station and public/private technology partnerships have made these industries possible, but today government represents only a small fraction of the total space enterprise.

The launchers that enable all this activity vary as much as their payloads. There are multiple types and sizes of expendable and reusable launchers, magnetic rail launchers, and airbreathing rockets. The infrastructure for building, processing and launching space vehicles is highly automated, reliable and efficient. Turnaround times for the latest reusable launch vehicles are hours or days, not weeks or months. Launch costs have been reduced by 50 to 100 times from 1998 levels, and reliability has improved by a factor of 10,000. Researchers and businesses have access to "launch on demand" that is affordable and reliable.

To fully realize the potential of space we need to create the "space highway of the 21st century." Like the interstate highway system, the shipping industry, the internet, and aviation, government involvement is critical as we begin to address the issue of space access in earnest. NASA is spending half a billion dollars over five years to reduce the fatal accident rate in aviation by a factor of 10. We need to reduce the accident rate of launch vehicles by a factor of 10,000 (to one failure in a million), and the cost by a factor of 10 to 100.

Achieving the Vision

There are three things government can and must do if we are to achieve this vision and truly open up the space frontier to the benefit of all Earth's inhabitants. We must invest in the high-risk technologies required for future launch vehicles, we must address the infrastructure problem, and we must foster industry's entrepreneurial spirit. Only when the commercial market, not government, is predominant in space will costs be driven down enough to make "launch on demand" a reality.

Technologies for Success
Consistent with the 1994 National Space Transportation Policy, the NASA Administrator intends to make a decision at the end of the decade on investments to significantly reduce NASA's launch costs. The decision will rest primarily on two things: the results of the industry-led Space Transportation Architecture Study, and the success of NASA's technology development and demonstration effort for next-generation reusable launch vehicles.

Industry, in the Space Transportation Architecture Study, is responsible for developing approaches that meet NASA's future space flight requirements with significant reductions in costs. NASA wants to be one of many customers of the launch industry. Our goal for the study is to have industry identify options that leverage the investment of the commercial launch industry and estimate the marginal cost to the government to meet NASA's unique requirements, such as crew exchange for the International Space Station. In this way, we hope to minimize NASA investment while encouraging innovative commercial approaches. Awards for the architecture studies were made to five aerospace companies earlier this month. We are delighted that both large and small companies are participating in the studies. When the studies are completed early next year, an independent assessment activity led by the NASA Chief Engineer will integrate these results into a future space transportation investment strategy that will feed into the FY 2001 budget process. The results of the studies will be widely available, and we expect broad involvement by NASA, DOD, and industry in formulating the investment strategy.

While the architecture study is providing a roadmap for future space transportation investments, NASA has for several years been investing in high-risk technologies for future space launch. Industry is factoring the results of these investments, especially of the Reusable Launch Vehicle program, into the architecture studies, and we fully expect that these technologies will pave the new space superhighway.

Affordable access to space is the primary objective of NASA's space transportation technology investments. NASA's goal is to provide technology that could reduce the payload cost to low-Earth orbit from $10,000 per pound to $1,000 per pound within 10 years, and to hundreds of dollars per pound within 20 years. Meeting this goal will require that the advanced technologies demonstrated by NASA are transferred to commercial use. Accordingly, NASA's Reusable Launch Vehicle (RLV) effort has incorporated a commercial focus from early technology planning through program implementation and evaluation. Innovative partnerships have been formed which strengthen the alliance between industry and government, eliminating unfocused technology and assuring convergence between commercial capabilities and National needs. Our RLV programs are providing technology which will be used by the private sector to meet future government and commercial launch needs. NASA's RLV effort will demonstrate technologies that lead to vehicles which require fewer people to operate, improve reliability through reusability, reduce infrastructure costs, and point the way to efficient, inexpensive access to space. The effort includes ground-based technology development through the Advanced Space Transportation Program (ASTP) and a series of flight demonstrators: the DC-XA Clipper Graham, the X-34 air-launched flight demonstrator, the X-33 advanced technology demonstrator, and Future-X vehicles.

ASTP is the ground-based technology program that expands technology investments across the entire set of space transportation architecture needs, including near-term RLV focused technology, airframe systems, propulsion systems, in-space transportation and revolutionary concepts for launch and in-space transportation. ASTP develops technologies to support flight vehicles that can validate low-cost space transportation concepts.

The DC-XA Clipper Graham flight tested the first-ever large-scale composite hydrogen tank, a new lightweight aluminum-lithium oxygen tank, and composite fuel lines, joints, and valves. The X-34, which will begin test flights in the spring of 1999, is an advanced technology demonstration vehicle which will fly at speeds up to Mach 8. The vehicle contains composite primary structures, control surfaces, and fuel tank, and will fly and land autonomously. X-34 is planned to demonstrate dramatic streamlining of vehicle operations, which is critical for reducing launch costs. A robust flight program will prove these technologies in a real-world environment.

The X-33, a suborbital demonstrator for a single-stage-to-orbit vehicle, is a larger and more aggressive experimental flight program than the X-34. It combines business planning with ground and flight demonstrations of advanced structures, materials, and propulsion system technologies to: 1) mature technologies required for a future operational system; 2) demonstrate the capability to achieve low development and operations cost; and 3) reduce business and technical risks to encourage commercial development and operation of a fully reusable launch system. The X-33 will begin flight testing no earlier than July 1999.

Beginning in FY 1999, NASA's Future-X program will continue technology development and demonstration for future launch vehicles through the use of experimental vehicles. In Future-X, we plan to build and fly a series of "Pathfinder" flight experiments. The primary purpose of these experiments is to demonstrate a small set of key technologies in flight. NASA will ensure that Pathfinders will be done quickly, at low cost, and will cover a wide range of potential space vehicle applications. Future-X is critical for ensuring a continuing infusion of new technology into the space launch industry to lower costs even further in the future. We look forward to receiving the first Future-X proposals from industry by October 1. We expect that many of the technologies identified for investment by the architecture studies will be explored in the Future-X program.

Providing the pre-competitive, high-risk technology necessary to bring down launch costs is an imperative of government that requires adequate, consistent, and long-term investment.

Reducing Infrastructure Requirements

Some of NASA's technology work will reduce the requirements for space launch infrastructure, leading to reduced costs. For example, instead of using up to seven environmentally hazardous propellants, we are developing technologies for launch systems that use two environmentally safe propellants – hydrogen and oxygen. The C-band, skin-tracking radars currently in use at the Federal Ranges will be rendered obsolete by Global Positioning System (GPS) tracking, which we are demonstrating in our technology programs. Modern scheduling tools are needed to replace the hand-held grease pencils used at the Ranges today. And the launch pad of the future can be seen at Edwards Air Force Base where the X-33 launch pad uses modern information technology.

Fostering the Entrepreneurial Spirit

Technology alone may not be sufficient to spur the commercial development of new launch vehicles which can provide the radical cost savings the country needs and which we believe will lead to the dramatic opening of the space frontier. Nor is it necessarily appropriate that technology demonstration be the government's only investment in the next generation of space transportation vehicles. These vehicles have great potential, but also entail great risk. This is especially true for full-scale development of a vehicle to meet the Government's unique requirements such as International Space Station crew exchange. The technical and business risk will likely be too high for private industry to go it alone. Some further government involvement, particularly in the form of incentives, could be required.

Lowering the cost of money for commercial launch vehicle development costs will play a key role in lowering launch costs. Many new space projects are perceived as high risk by the investment community, leading to exorbitant interest rates. Junk bond rates are routine. Paying these rates makes new space launch ventures too expensive. NASA's analysis shows that if industry could raise enough private capital to build a large reusable launch vehicle, the cost per pound to low-Earth orbit could be around $2500. However, with government incentives lowering the cost of money, the cost could meet NASA's goal of $1000 per pound. The contrast is stark, and could make all the difference in opening up space.

With this in mind, NASA recently completed an internal study of potential government incentives for the launch industry. We examined a wide range of possible incentives and evaluated them according to the following criteria:

- Encourages private sector investment (reduced cost, increased availability of capital)

Allows risk sharing with private sector

Minimizes government budget requirements

Takes advantage of government and market best capabilities

Allows market forces to choose winners and losers

Facilitates U.S. Government's ability to meet flight requirements in the near term while broadening opportunities for commercial space transportation development.

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Our assessment favored four types of incentives:

- Research and development support – This could include in-house research and development for precompetitive, high-risk critical technologies, devotion of resources through a cooperative agreement, or a non-reimbursable agreement. R&D support would retire a project's technical risk, making it more attractive for private sector investment. From NASA's perspective, R&D support may be the most beneficial government incentive.

- Government guaranteed loan – We believe this cornerstone of S. 2121 can be an effective incentive. A government guaranteed loan can reduce the cost of capital while allowing a larger amount to be borrowed. This enables lower costs once the new system is operating, benefiting both government and commercial users. In order to ensure the private sector bears an appropriate share of risk, any government guarantee must be contingent on industry first securing private investment. Private investors would be required to certify that the project meets a minimum threshold of technology readiness. To further assure the government doesn't bear a disproportionate share of risk, we recommend identifying some reasonable limit on the percentage of a project's value which can be guaranteed.

- Advance purchase agreement – For vehicles that could meet a government launch requirement, some type of advance purchase agreement can act as an incentive to private sector development. Under such a scenario, the government would guarantee to purchase a certain number of launches if industry can meet a designated low price and schedule. To protect the government's investment, those who qualify for a guaranteed advance purchase would be required to provide the government with an option to purchase a certain number of additional launches at the same price. While this incentive is currently not included in S. 2121, we believe it could be linked to government guaranteed loans providing the U.S. Government an additional benefit in return for its early investment. For example, projects which qualify for advance purchase agreement could qualify for a guaranteed loan for a higher percentage of the project.

- Tax credit/holiday – A tax credit could be provided for money spent by the private sector on full-scale development and could be modeled on the research and experimentation tax credit. A tax holiday could provide that gross income would not include income derived from products manufactured in outer space or from services provided in outer space. A tax holiday would most directly benefit the customers of launch providers. A tax credit, on the other hand, would be of more immediate benefit and interest to launch providers themselves.

NASA believes a balanced set of incentives will likely be the most successful route to lowering the cost of space access.

Conclusion

Affordable, reliable access to space is indispensable to the further opening of the space frontier for science, research, commerce, and exploration. NASA and DOD together spend over $6 billion on space launch, and that is without the cost of the infrastructure factored in. Over 25 years this is $150 billion. If we can reduce that by a factor of 10, our goal, we will cut costs to $15 billion, saving $135 billion. As great as the effect of that magnitude of savings would be for the government, the effect on the commercial sector would be even greater. In 1997 commercial interests spent almost $3 billion on space launch. If launch costs are cut by a factor of 10, not only will current space businesses reap the benefits, but entire new industries will blossom. Once it becomes cost-effective to do business in space, the sky is no longer the limit.

To achieve this magnitude of savings for the future requires an investment today. NASA should and will continue doing its part through an aggressive program to provide the technologies necessary for future privately owned and operated reusable launch vehicles. We also are examining, in a systematic way, future space transportation architectures which will feed into an Administration decision by the end-of-the-decade on development of a next-generation reusable space transportation system. Because of the high technical and market risk inherent in developing these vehicles, and because the Government will be a large customer for launch services and benefit from lower costs, we believe it is appropriate for the government to provide incentives to the private sector. NASA appreciates the commitment of Senator Breaux to lowering launch costs by sponsoring the Space Launch Cost Reduction Act, and thanks Senator Frist for holding this important hearing today. We look forward to continuing to work with them, and the rest of the Subcommittee, to achieve our goals for affordable access to space.